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CLOVER STEM-BORER AS AN ALFALFA PEST.

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INTRODUCTION.

The clover stem-borer (fig. 1) (*Languria mozardi* Latr.) has been known for a great many years, and is often briefly referred to in literature as a pest of red and mammoth clovers. In 1909 Prof. J. W. Folsom (16)[1] recorded many important facts regarding its life history and habits as an enemy of clover. The larvæ or young subsist upon the pith eaten from the center of the clover stems.

During recent years, especially in the southwestern semiarid and irrigated regions, the beetle has been discovered feeding upon alfalfa (*Medicago sativa*) and has become a pest of considerable importance to alfalfa culture. The young borer, as in the case of clover injury, eats the center of an alfalfa stem and causes it to become woody and possibly to break off and lodge.

The present paper is a complete account of the life history and habits of the insect as an enemy to alfalfa culture as well as a discussion of methods of controlling the pest.

EARLY HISTORY.

The clover stem-borer is distinctly a native of America, not being listed in European catalogues. The earliest record of it is in 1807,

[1] Figures in parenthesis refer to "Literature cited," p. 24.

by Latreille (1, p. 66), who described it and named it after Mozardi from specimens received from the United States. In 1828, Say (2) redescribed it and published the first figure of the adult beetle. It is mentioned by Lamarck (3, p. 486) in 1835, and nearly a half century after its first description it was listed by Melsheimer (4, p. 47) in his catalogue of the Coleoptera of the United States, while Leconte (5) mentions it a year later than this as occurring in the "Middle, Southern, and Western States." Motschulsky (6, p. 241) in 1867 reports it from North America, principally in Louisiana, and mentions it as common on cruciferous plants, and in 1873 Crotch (7) redescribes the species in detail and gives its habitat as Washington, Pennsylvania, Kansas, Nebraska, and the Southern States.

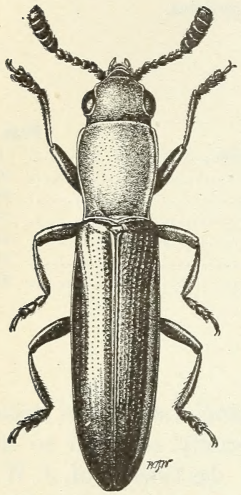

FIG. 1.—Adult of the clover stem-borer (*Languria mozardi*).

It is noticeable that in all these records no mention is made of the habits of the insect either in the young or adult stages, although for a good many years previous to 1879 the beetle had been frequently taken by collectors. It remained for Prof. J. H. Comstock (8, p. 199) in 1879 to discover that the larva of this beetle lives as a borer within the stems of red clover, and in the Report of the Entomologist for that year he records some of the discovered larval and adult habits. This short report stimulated further study, and in 1881 Lintner (9) gave the known history of this insect a prominent place in his excellent paper on "The insects of the clover plant." In 1886 Webster (10) noted what was doubtless the larva of this species feeding in timothy. In 1890 Chittenden (12) reported several plants of the Compositae as being hosts of this insect, while the same year Weed (13) published a summary of the known food plants and added a few new life-history notes. In 1894 Davis (14, p. 167) gave a brief account of this insect, and in 1907 Girault (15) made some interesting notes on the act of oviposition. The most recent and complete report was published by Prof. J. W. Folsom (16) in 1909. In all these published records the insect has always been treated as an enemy of clover, no mention having been made of it as a depredator on alfalfa.

DISTRIBUTION.

At the present time the clover stem-borer is known to inhabit practically all of the United States, as well as parts of Canada and northern Mexico. In 1909, Folsom (16) stated: "It inhabits the Middle

and the Southern States, some of the Western States, and parts of Canada." Members of the force of the Bureau of Entomology have collected it at the following places:

T. H. Parks:
Asheville, N. C.
Arlington, Va.
Chevy Chase, Md.
Wellington, Kans.
E. H. Gibson:
Nashville, Tenn.
Buena Vista, Tenn.
A. B. Gahan:
Jackson, Tenn.
Chattanooga, Tenn.
W. E. Pennington:
Meyersville, Md.
Hagerstown, Md.
G. G. Ainslie: Hurricane Mills, Tenn.
W. H. Larrimer: Nashville, Tenn.
F. M. Webster: Lafayette, Ind.
V. A. Roberts: Oxford, Ind.
E. O. G. Kelley:
Dow, Ill.
Coulterville, Ill.
P. Hayhurst: Wellington, Kans.
J. A. Hyslop: Wolfville, Md.
C. N. Ainslie: Wolsey, S. Dak.

The authors have taken it, in various localities, in Lower California, Mexico, and in California, Arizona, New Mexico, and Texas.

It is not only of wide distribution but it inhabits localities of widely different altitudes, occurring in the Imperial Valley of California, 250 feet below sea level, and at Ash Fork, Ariz., at an elevation of 5,148 feet. It is especially abundant, however, in the eastern and central red clover districts and reaches its greatest numbers in the southern and southwestern alfalfa districts.

FOOD PLANTS.

The two cultivated plants that seem to be the favorite food for the larva of this beetle are alfalfa and red clover. Besides these, the insect has a great variety of host plants, many of which belong to the Compositae. Fortunately many of these plants are weeds, the destruction of which will aid in the control of the depredator. A complete list of food plants with authority for each is given below:

Alfalfa (*Medicago sativa*)	V. L. Wildermuth.
Red clover (*Trifolium pratense*)	J. H. Comstock.
White sweet clover (*Melilotus alba*)	C. M. Weed.
Yellow sweet clover (*Melilotus officinalis*)	F. H. Gates.
Bur clover (*Medicago hispida*)	V. L. Wildermuth.
Timothy (*Phleum pratense*)	F. M. Webster.
Sunflower (*Helianthus annuus*)	Gates and Wildermuth.
Ox-eye daisy (*Chrysanthemum leucanthemum*)	F. H. Chittenden.
Daisy fleabane (*Erigeron ramosus*)	F. H. Chittenden.
Prick fleabane (*Erigeron philadelphicus*)	C. M. Weed.
Mares tails (*Erigeron canadensis*)	C. M. Weed.
Thistle (*Cnicus altissimus*)	C. M. Weed.
Trumpet weed (*Lactuca canadensis*)	C. M. Weed.
Wild lettuce (*Lactuca floridana*)	C. M. Weed.
Cone-flower (*Rudbeckia laciniata*)	C. M. Weed.
Yarrow (*Achillea millefolium*)	C. M. Weed.
Tall nettle (*Urtica gracilis*)	C. M. Weed.

Stinging nettle (*Urtica dioica*)	F. H. Chittenden.
Tall bellflower (*Campanula americana*)	C. M. Weed.
Horse-weed (*Ambrosia trifida*)	F. H. Chittenden.
Ragweed (*Ambrosia artemisiaefolia*)	C. M. Weed.
Daisy (*Leucanthemum* sp.)	A. A. Girault.
Wheat grass (*Agropyron* sp.)	C. N. Ainslie.
Marsh grass (*Spartina michauxiana*)	C. N. Ainslie.
Burdock (*Arctium minus*)	H. L. Parker.
Malva (*Malva rotundifolia*)	F. H. Gates.
Marsh grass (*Spartina cynosuroides*)	P. Hayhurst.

ECONOMIC IMPORTANCE OF THE INSECT TO ALFALFA AND CLOVER.

A great many farmers in the alfalfa-growing sections of the country, especially those of the Southern and Southwestern States, do not appreciate to how great an extent this borer is responsible, at certain times, for the poor, woody quality of their alfalfa hay. Nor do farmers in the eastern section of the country appreciate the small but nevertheless direct damage this borer exerts upon the productiveness of red and mammoth clovers.

It is not at all surprising that this condition exists, for the borer is hidden from view at all times, traveling up and down the center of an alfalfa stalk where the adult deposited the egg, and devouring the entire center of the stem, leaving a woody fibrous stalk that is deficient in foliage and high in crude fiber content. An infested stalk of alfalfa, during the heat of the day, will often show wilting from lack of a proper amount of water reaching the plant. This, of course, checks plant growth, and the wilting will usually cause the lateral leaves to fall; hence, an infested plant will have lost a large amount of its foliage.

In 1909, Folsom (16) said: "Were this insect more numerous it might gradually develop into a pest of considerable importance." In the southwestern United States, where it is widely distributed, the extent of the damage may be realized when we know that as high as 85 per cent of the stalks in an alfalfa field often are infested with this borer. This means that 85 per cent of the hay crop in that field will have stalks of a woody nature. It also means that a certain percentage of these stalks will have broken off and fallen and probably entirely lost their foliage. The result is a hay crop lacking leaves, high in crude fiber, and of a grade altogether inferior to that which might have been produced had this insect not been present.

Regarding the effect of the feeding of the larva on a clover stem, Comstock (8, p. 199) says:

> While they do not kill the stem outright, they gradually weaken it and eventually cause its destruction, having also, of course, a very injurious effect upon the maturing of the seed.

Folsom (16), in his discussion of the effect upon clover, states:

The chief effect of the stem borer is, however, a mechanical one. The stems that are hollowed out fall to the ground prematurely, though not until they have attained a considerable size. One can find the borers most abundantly in the large prostrate stems rather than in the stems that remain erect. The plants that lodge carry their flowers to the ground, become soiled with dirt, and are not easy to mow.

Thus it is obvious that practically the same condition exists in the red-clover regions as in the alfalfa regions of the Southwest, only in the case of red clover the insect has never reached the excessive numbers that occur in the extensive alfalfa regions of the Southwest. This is doubtless due to the fact that only one generation annually is found in the former section of the country, while in the latter there are always three generations each year. When it is realized that this borer inhabits the whole of the United States, it can readily be seen that the annual toll taken by it from the farmers of this country runs into high figures.

DESCRIPTION.

THE ADULT.

The beetle (fig. 1) is slender and has a shiny appearance. The head and thorax are a deep red, while the remainder of the insect is a bluish-black. The surface of the elytra is indented by regular rows of punctures. The species was originally named and briefly described by Latreille (1), but considerably later redescribed in detail by Crotch (7, p. 350), whose description is as follows:

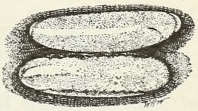

FIG. 2.—Eggs of the clover stem-borer.

Elongate, parallel, red, antennæ (except the base) and apical half of the femora black, tibiæ and tarsi brown, elytra bluish-green; head and thorax sparingly punctate, the latter elongate, the sides rounded in front, basal striolæ short; scutellum red; elytra punctate striate, interstices impunctate; underside sparingly punctate, 2–3 last ventral segment black. L. .22–.31 inch.

THE EGG.

The egg (fig. 2) is a very small, light cream-yellow, bean-shaped object from 1.5 mm. to 2 mm. long and about 0.5 mm. in diameter. Folsom (16) described it as:

Translucent cream-yellow, paler at each end, elliptico-cylindrical and slightly curving, with one end slightly more tapering than the other.

The eggs that the authors have observed vary greatly in color, newly laid eggs being almost white or colorless, while fully incubated eggs are a deep chrome-lemon color.

THE LARVA.

The larva (fig. 3) is exceptionally slender and is pale yellow in color. The very small and inconspicuous, although well-developed, feet, together with the quick wriggling movement of the larva in its burrow, give it much the appearance of a worm.

Comstock (8, p. 200) as early as 1879 gave a complete description of a full-grown larva, which is as follows:

Length 8mm; color light yellow; tips of mandibles and anal horn brown. Subcylindrical in shape, the anal segment only being narrower than the preceding joint. Average width .9mm. Thoracic legs long and stout; only one prop leg, which is under the anal segment. The anal segment is armed upon its dorso-posterior border with two upward-curved acute hooks placed close together. The head is broad, somewhat flattened dorso-ventrally. Antennæ prominent, 4-jointed, 3d joint longest, 4th joint slender. Labrum broad, rounded, with a row of small piliferous tubercles at its anterior border. Mandibles, 3 toothed. Maxillary palpi, 3 jointed. Labrum rounded anteriorly; labial palpi 2 jointed, stout.

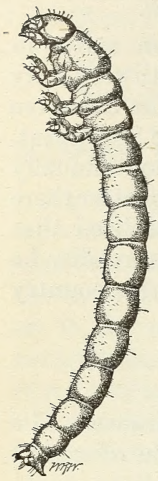

FIG. 3.—Full-grown larva of the clover stem-borer.

THE PUPA.

The pupa (fig. 4) is yellow, slender, and semicylindrical. The abdomen is darker in color than the rest of the body. The head is broader than either the thorax or abdomen, and the wing pads are prominent. The abdominal segments have short spines dorsally, by the aid of which the insect moves up and down the stem.

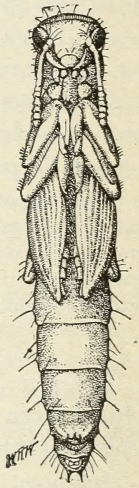

FIG. 4.—Pupa of the clover stem-borer.

LIFE HISTORY AND HABITS.

THE LIFE CYCLE.

The average time required for this beetle to pass its complete life cycle is about 60 days. This period is noticeably shorter during the first generation than during later generations. This is due to the fact that during this generation the time elapsing from the issuance of the adult to copulation and oviposition is considerably shorter than in the subsequent generations. The apparent cause for this is that later in the year the beetles tend to cease their activities for the season rather than to continue a third and sometimes a partial fourth generation. The life cycle is shorter during the first generation in spite of the fact that the egg stage is considerably longer than during the months of July and August. (See rearing cage, fig. 5.)

The minimum life cycle has been noted to be as low as 50 days, while the maximum has often extended through a period of 65 to 70 days. The total length of the egg, larval, and pupal periods was found to average 49.1 days, with a minimum of 45 days and a maximum of 58 days. Table I shows the combined length of egg, larval, and pupal periods of 20 specimens carried through, by the junior author, from egg to adult, but does not show the period existing between issuance of adult and oviposition.

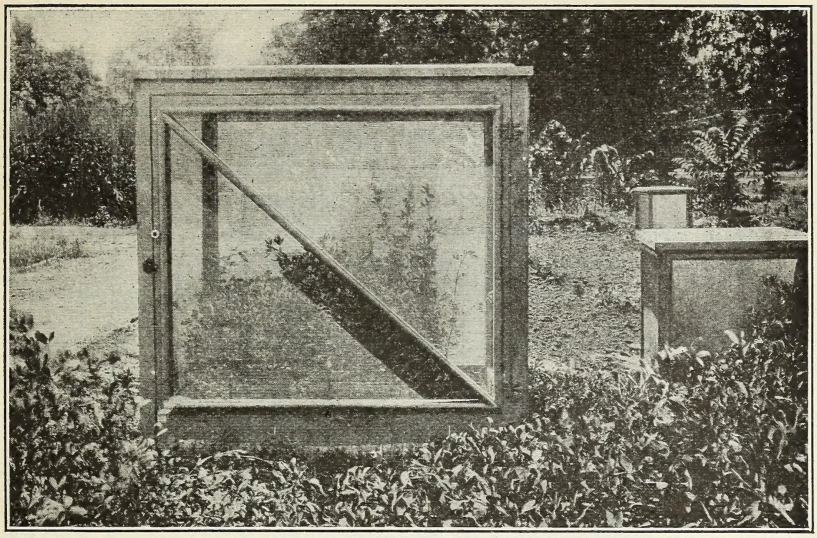

FIG. 5.—Type of cage used in generation records of the clover stem-borer on alfalfa.

TABLE I.—*Duration of life cycle of the clover stem-borer in alfalfa at Tempe, Ariz.*

[Observer, Gates.]

Cage No.	Eggs.				Date of pupation.	Length of larval stage.	Date adult issued.	Length of pupal stage.	Total length of life cycle.	Average mean temperature.
	Date laid.	Date hatched.	Number.	Length of stage.						
	1915.	1915.		*Days.*	1915.	*Days.*	1915.	*Days.*	*Days.*	°*F.*
T 100–1	Apr. 2	Apr. 5	1	3	May 15	40	May 24	9	52	66
T 100–2	...do...	...do...	1	3	...do...	40	May 29	14	57	66
T 100–3	...do...	Apr. 6	1	4	May 17	41	May 25	8	53	65
T 104	Mar. 29	Apr. 1	1	4	May 12	41	May 19	7	52	60
T 104–1	Mar. 30	Apr. 4	1	4	May 15	41	May 24	9	54	65
T 104–2	Apr. 7	Apr. 10	1	3	May 17	37	May 25	8	48	60
T 104–3	Apr. 9	Apr. 12	1	3	May 15	33	...do...	10	46	60
T 104–4	...do...	...do...	1	3	May 17	35	May 28	11	58	65
T 115	...do...	...do...	1	3	May 25	43	June 2	8	54	66
T 492	Aug. 18	Aug. 21	1	3	Sept. 17	37	Sept. 25	8	48	70
T 784	Sept. 3	Sept. 7	1	4	Oct. 8	31	Oct. 18	10	45	76
T 791	Sept. 5	Sept. 9	1	4	Oct. 10	31	Oct. 22	12	47	75
T 791–2	...do...	...do...	1	4	...do...	31	Oct. 23	13	48	75
T 791–3	...do...	...do...	1	4	Oct. 11	32	Oct. 25	14	50	75
T 795	Sept. 6	Sept. 11	1	5	Oct. 10	30	Oct. 20	10	45	73
T 876	...do...	...do...	1	5	Oct. 12	32	Oct. 24	12	49	73
	1916.	1916.			1916.		1916.			
T 1398–2	Mar. 12	Mar. 18	3	6	Apr. 20	34	Apr. 26	6	46	64
T 1405–2	Mar. 20	Mar. 25	1	5	Apr. 24	32	May 3	9	46	72
Total or average	.....	.....	20	4.1	.....	35.5	.....	9.5	49.1	.....

TABLE II.—*Length of egg stage of the clover stem-borer (Languria mozardi) in alfalfa at Tempe, Ariz.*

Cage No.	Observer.	Eggs.				Length of stage.	Average mean temperature.
		Date laid.	Number.	Date hatched.	Number.		
		1914.		1914.		*Days.*	°*F.*
1	Newton	June 25	3	June 28	2	3	74
		1912.		1912.			
2	Wildermuth	July 30	1	Aug. 1	1	2	84
10	do	Aug. 6	1	Aug. 8	1	2	89
		1916.		1916.			
T 1787–1	do	June 14	2	June 19	2	5	82
T 1787–2	do	June 15	1	June 20	1	5	82
T 1787–3	do	June 17	2	do June 21	1 1	3 4	81 80
T 1787–4	do	June 22	1	June 25	1	3	79
T 1787–5	do	do	2	do	2	3	79
T 1787–6	do	do	2	June 26	2	4	79
T 1787–7	do	June 23	1	do	1	3	79
T 1787–8	do	June 24	1	June 27	1	3	80
T 1442–1	Gates	Mar. 20	14	Mar. 23 Mar. 25 Mar. 26	2 2 1	3 5 6	63 59 58
T 99–3	do	Apr. 2	1	Apr. 8	1	6	62
T 99–7	do	do	1	Apr. 9	1	8	62
T 100	do	do	4	Apr. 5 Apr. 6	2 1	3 4	60 61
T 1405–1	do	Mar. 15	7	Mar. 20 Mar. 21	2 1	5 6	67 67
T 1405–2	do	Mar. 20	18	Mar. 23 Mar. 25	5 2	3 5	63 59
T 1837	do	July 11	9	July 14	5	3	84
Total or average			71		41	3.8	

EGG.

The eggs are deposited in the stem of the host plant, and in the case of alfalfa are deposited when the alfalfa has reached a stage of growth about 8 to 10 inches high. The adults always seem to prefer young, new-growing, and succulent alfalfa for oviposition. This apparently is contrary to observations made by Folsom and others that the females choose the older and more mature red-clover stems for oviposition. The eggs are deposited through a round opening in the stem made by the female and are always placed within a cavity made in the pith.

The average length of the incubation period, as given in Table II, for 41 eggs is 3.8 days, with a minimum of 2 days and a maximum of 8 days. While the average time required for incubation is lower during periods of higher temperature, yet this variation is not always due to temperature conditions, for eggs under observation hatched in 3 days during the month of April, when the average mean temperature was 60° F., while others during the month of June often required 4 or 5 days for incubation when the temperature was 20° higher.

It will be noted that these egg-stage lengths compare very favorably with the egg stage as reported by Folsom for Illinois. He found the egg stage to be 5 days in length during May, while during July it was only 3 days.

LARVA.

DURATION OF THE LARVAL STAGE.

The duration of the larval stage is about 35 days under all conditions of temperature and moisture. Table III shows that 35 specimens averaged 34.5 days with a minimum of 24 days and a maximum of 54 days. This wide variation in time is due not so much to temperature as to an inclination of the larva to prolong the fourth instar, even after it is apparently full grown, previous to pupation, as at this time it rests for an indefinite period before the pupa is fully formed and the last larval skin is shed.

TABLE III.—*Length of larval stage of the clover stem-borer (Languria mozardi) in alfalfa at Tempe, Ariz.*

Cage No.	Observer.	Date eggs hatched.	Date larvæ pupated.	Length of larval stage.	Average mean temperature.
		1912.	1912.	*Days.*	°*F.*
10	Wildermuth	Aug. 8	Sept. 4	27	84
		1915.	1915.		
	Gates	Apr. 19	May 24	35	67
T 99–3	do	Apr. 8	May 12	34	62
T 99–5	do	Apr. 5	May 10	33	63
T 99–7	do	Apr. 9	May 3	24	64
T 100–1	do	Apr. 5	May 15	40	64
T 100–2	do	do	do	40	64
T 100–3	do	Apr. 6	May 17	41	65
		1916.	1916.		
T 1823–4	Wildermuth	June 22	July 23	31	85
T 1823–5	do	do	do	31	85
T 1823–7	do	do	Aug. 2	41	86
T 1823–9	do	June 23	Aug. 7	45	88
T 1823–10	do	do	Aug. 16	54	83
T 1823–13	do	do	do	54	83
T 1823–14	do	do	July 28	36	82
T 1823–18	do	June 24	July 24	30	82
T 1823–19	do	do	Aug. 4	41	85
T 1823–20	do	do	Aug. 7	44	85
T 1823–22	do	June 30	July 26	26	86
T 1823–25	do	July 16	Aug. 16	31	83
T 1823–26	do	do	Aug. 25	40	83
T 1823–27	do	do	Aug. 19	34	83
T 1823–28	do	do	Aug. 14	29	83
T 1823–31	do	June 17	Aug. 21	35	83
T 1823–35	do	do	Aug. 11	25	83
T 1823–37	do	do	Aug. 25	39	78
T 1823–38	do	do	Aug. 21	35	83
T 1823–41	do	June 18	Aug. 14	27	83
T 1823–46	do	do	Aug. 18	31	83
T 1823–47	do	do	Aug. 12	25	80
T 1823–48	do	do	do	25	80
T 1823–49	do	do	Aug. 26	39	82
T 1823–58	do	June 19	Aug. 16	28	83
T 1823–59	do	do	Aug. 21	33	82
T 1823–62	do	June 20	Aug. 24	35	82
Average				34.5	

The larvæ pass through four molts (see Table IV) and five instars. In experiments conducted by the authors and tabulated below only three larvæ were reared successfully from egg to pupa with a complete record of the number of molts and instars. This was due to the fact that the larvæ naturally feed within the alfalfa stem and can not be

continuously observed under these conditions. Since the larvæ also, immediately after molting, consume the cast larval skin, it is impossible to find the remains of the molt by dissecting the stem. An attempt was made, therefore, to secure the number of molts and instars by splitting an alfalfa stem down the center, making an artificial cavity in the split half, and fitting this tightly against the side of a long glass tube. The larva was then placed therein and by these means a continual view of the larva was maintained, and thus in three cases records of molts and instars were obtained. Unfortunately, however, the data regarding the lengths of these instars are doubtless quite inaccurate, since the larvæ appeared to hurry their development and pass through to adults as quickly as possible. Apparently this was due to the fact that the larvæ were under unnatural conditions, such as being exposed to light and the glass. The three specimens reared were undersized, and an attempt at rearing almost a hundred others met with failure.

TABLE IV.— *Molts and instars of the clover stem-borer (Languria mozardi) in alfalfa at Tempe, Ariz., 1916.*

Cage No.	Date egg hatched.	Date of first molt.	Length of first instar.	Date of second molt.	Length of second instar.	Date of third molt.	Length of third instar.
			Days.		*Days.*		*Days.*
1	Apr. 9	Apr. 14	5	Apr. 17	3	Apr. 21	4
2	...do....	...do....	5	...do....	3	...do....	4
3	...do....	...do....	5	...do....	3	...do....	4

Cage No.	Date of fourth molt.	Length of fourth instar.	Date of pupation.	Length of fifth instar.	Total length of larval stage.	Average mean temperature.
		Days.		*Days.*	*Days.*	°*F.*
1	Apr. 26	5	May 7	11	28	68
2	...do....	5	May 10	14	31	69
3	Apr. 27	6	May 8	11	29	69

THE LARVAL HABITS.

The larva, upon hatching, at first feeds within a quarter-inch cavity constructed by the adult before depositing the egg, but after a day or so begins to eat its way, first through the pith and later through both the pith and softer inner portions of the wall of the stem until it finally has a large cavity with only the thin hard exterior wall of the stem remaining. The larva gradually enlarges this tunnel, working its way both up and down the stem until often the entire length of the stem is traversed. The length of the tunnel usually is limited only by the length of the individual stem infested. Measurements of these tunnels show maximum lengths to be 30 inches. The larva is especially active and travels up and down the tunnel with a

quick wriggling motion. The wall of the tunnel often becomes so thin as to cause wilting of the plant, and in such cases the stem usually falls to the ground, so that in an alfalfa field damaged by this insect the infested stems nearly always either fall on the ground or lodge one against another.

The larva, upon the completion of its feeding period, constructs a cell within which to pupate. This cell is usually 8 to 10 inches long and is sealed at both ends with frass and excrement mixed with a secretion similar to saliva, which the larva ejects at the time of constructing the cell.

It is impossible for either the larva or pupa of this species to continue its development after a hay crop is cut and put in the stack or baled. During the fall of 1915 the junior author made many observations bearing upon this point, his record of which follows:

> During the past month many stems from hay stacks of the past season's cutting have been dissected. In a large percentage of the stems there has been evidence of Languria injury, and in many of the stems larvæ and pupæ were found. These larvæ and pupæ were all dead and dried up, giving evidence that the development is stopped when the hay is cut and put in the stack. Stalks from hay that has been baled have also been dissected and the above conditions are true of the baled hay also.

PUPA.

DURATION OF THE PUPAL STAGE.

The pupal stage for all temperatures for a total of 130 specimens averaged about 9 days, as is shown in Table I, and also in Table V, which follows. Twenty-six specimens, during the months of July and August, averaged 5.6 days (see Table VI). The minimum length was found to be 3 days during the month of July with a maximum of 18 days during the month of June.

Pupation takes place within the cell constructed by the larva, requiring often several hours for the shedding of the larval skin. The larva first attaches itself by the anal cerci to the bottom of the tunnel, and by means of this attachment the pupa very easily detaches itself from the cast skin. This last larval skin is always found attached at the place mentioned.

The pupa is exceedingly active, and as in the case of the larva moves with freedom up and down this 8 or 10 inch tunnel by means of the wriggling movement which has already been mentioned as being characteristic of the larva.

TABLE V.—*Length of pupal stage of the clover stem-borer (Languria mozardi) in alfalfa at Tempe, Ariz.*

Cage No.	Observer.	Date of pupation.	Date adult issued.	Length of pupal stage.	Average mean temperature.
		1912.	1912.	*Days.*	°*F.*
2	Wildermuth	Aug. 4	Aug. 14	10	86
10	do	Sept. 4	Sept. 13	9	75
		1914.	1914.		
100	J. H. Newton	July 30	Aug. 4	5	93
100	do	July 31	Aug. 5	5	93
		1915.	1915.		
	Gates	May 28	June 6	8	76
	do	May 30	June 7	8	76
T 781	do	Sept. 22	Sept. 29 (adults).	7	74
T 781	do	do	Oct. 1 (3 adults).	9	73
T 996	do	Oct. 3	Oct. 12	9	71
T 996	do	Oct. 7	Oct. 17	10	68
T 371	do	July 26	Aug. 2 (3 adults).	8	82
T 394	do	Aug. 22	Aug. 30	8	84
T 395	do	Aug. 29	Sept. 5	7	81
T 779	do	Sept. 5	Sept. 15	10	77
T 779	do	Sept. 8	Sept. 16	8	76
T 779	do	Sept. 10	Sept. 19	9	77
T 779	do	Sept. 12	Sept. 20	8	77
T 779	do	do	Sept. 22	10	78
T 994-1	do	Oct. 1	Oct. 10	9	73
T 994-2	do	Oct. 8	Oct. 18	10	69
T 994-3	do	Oct. 9	Oct. 20 (2 adults)	11	68
	do	June 1	June 8	7	76
	do	June 15	June 24	9	82
	do	do	June 25	10	82
T 393	do	Aug. 20	Aug. 29	9	84
T 781	do	Sept. 20	Sept. 29	9	76
T 99-2	do	May 10	May 22	12	72
T 99-3	do	May 12	May 23	11	72
T 99-5	do	May 10	May 19	9	72
T 100-1	do	May 15	May 24	9	71
T 100-2	do	do	May 29	14	72
T 100-3	do	May 17	May 25	8	71
		1916.	1916.		
T 1671-1	Wildermuth	May 9	May 22	13	71
T 1671-2	do	do	May 23	14	71
T 1671-3	do	May 13	do	10	70
T 1671-4	do	May 15	May 25	10	69
T 1671-5	do	do	May 24	9	69
T 1671-6	do	do	May 26	11	68
T 1671-7	do	do	May 25	10	69
T 1671-8	do	May 16	May 24	8	70
T 1671-9	do	May 18	May 30	12	69
T 1671-10	do	do	May 29	11	68
T 1671-11	do	do	May 31	13	69
T 1671-12	do	May 19	June 6	18	70
T 1671-13	do	do	May 31	12	69
T 1671-14	do	do	do	12	69
T 1671-15	do	do	May 30	11	68
T 1671-16	do	May 22	June 1	10	69
T 1671-17	do	do	do	10	69
T 1671-18	do	do	May 31	9	69
T 1671-19	do	May 23	June 3	11	69
T 1671-20	do	do	do	11	69
T 1671-21	do	May 24	June 5	12	70
T 1671-22	do	May 25	June 6	12	71
T 1671-23	do	May 26	do	11	71
T 1671-25	do	do	do	11	71
T 1671-26	do	May 27	do	10	72
T 1671-27	do	do	do	10	72
T 1671-28	do	do	do	10	72
T 1671-29	do	May 29	do	8	73
T 1671-30	do	do	June 7	9	73
T 1671-31	do	do	June 6	8	73
T 1671-32	do	do	do	8	73
T 1671-34	do	do	do	8	73
T 1671-35	do	do	June 7	9	73
T 1671-36	do	do	June 6	8	73
T 1671-37	do	do	do	8	73
T 1671-38	do	do	do	8	73
T 1671-39	do	do	June 7	9	73

TABLE V.—*Length of pupal stage of the clover stem-borer (Languria mozardi) in alfalfa at Tempe, Ariz.*—Continued.

Cage No.	Observer.	Date of pupation.	Date adult issued.	Length of pupal stage.	Average mean temperature.
		1916.	1916.	*Days.*	°*F.*
T 1671-40	Wildermuth	May 29	June 7	9	73
T 1671-41	do	do	do	9	73
T 1671-42	do	do	do	9	73
T 1671-43	do	May 30	June 6	7	73
T 1671-44	do	do	June 8	9	74
T 1671-45	do	do	do	9	74
T 1671-46	do	May 31	June 9	9	75
T 1671-47	do	June 1	do	8	76
T 1671-48	do	do	June 8	7	75
T 1671-49	do	do	June 9	8	76
T 1671-50	do	do	June 8	7	75
T 1671-51	do	do	June 9	8	76
T 1671-52	do	do	do	8	76
T 1671-53	do	June 2	June 10	8	77
T 1671-54	do	June 3	June 12	9	78
T 1671-55	do	do	do	9	78
T 1671-56	do	do	do	9	78
T 1671-57	do	June 5	June 14	9	79
T 1671-58	do	do	June 12	7	79
T 1671-59	do	do	do	7	79
T 1671-60	do	do	June 14	7	79
T 1671-60	do	do	June 12	7	79
T 1671-61	do	do	do	7	79
T 1671-62	do	do	do	7	79
T 1671-63	do	do	June 14	9	79
T 1671-64	do	June 6	do	8	80
T 1671-65	do	do	do	8	80
T 1671-66	do	do	do	8	80
T 1671-67	do	June 7	do	7	80
T 1671-68	do	do	do	7	80
T 1671-69	do	do	do	7	80
T 1671-70	do	June 9	June 16	7	81
T 1671-71	do	do	do	7	81
T 1671-72	do	June 10	June 17	7	82
T 1671-73	do	June 12	do	5	83
Average				9	

TABLE VI.—*Length of pupal stage of the clover stem-borer (Languria mozardi) in alfalfa at Tempe, Ariz., 1916.*

Cage No.	Observer.	Date of pupation.	Date adult issued.	Length of pupal stage.	Average mean temperature.
				Days.	°*F.*
T 1823-4	Wildermuth	July 23	July 26	3	88
T 1823-5	do	do	do	3	88
T 1823-7	do	Aug. 2	Aug. 9	7	85
T 1823-9	do	Aug. 7	Aug. 12	5	85
T 1823-10	do	Aug. 16	Aug. 23	7	80
T 1823-14	do	July 28	Aug. 2	5	89
T 1823-18	do	July 24	July 30	6	86
T 1823-19	do	Aug. 4	Aug. 9	5	87
T 1823-20	do	Aug. 7	Aug. 14	7	84
T 1823-22	do	July 26	Aug. 2	7	87
T 1823-25	do	Aug. 16	Aug. 23	7	80
T 1823-26	do	Aug. 25	Sept. 1	7	84
T 1823-27	do	Aug. 19	Aug. 26	7	81
T 1823-28	do	Aug. 14	Aug. 21	7	79
T 1823-31	do	Aug. 21	Aug. 28	7	83
T 1823-37	do	Aug. 25	Sept. 1	7	84
T 1823-38	do	Aug. 21	Aug. 28	7	83
T 1823-41	do	Aug. 14	Aug. 22	8	74
T 1823-46	do	Aug. 18	Aug. 26	8	80
T 1823-47	do	Aug. 12	Aug. 19	7	80
T 1823-48	do	do	do	7	80
T 1823-49	do	Aug. 26	Sept. 2	7	85
T 1823-58	do	Aug. 16	Aug. 23	7	80
T 1823-59	do	Aug. 21	Aug. 28	7	83
T 1823-62	do	Aug. 24	Aug. 30	6	84
T 1490	Gates	Apr. 28	May 8	10	72
Average				6.5	

ADULT.

The adult, after issuing from the pupa, often spends a period of time varying from two days to several weeks in the cavity within the alfalfa stem. The adults arising from the first generation nearly all emerge within a few days after becoming mature, while those issuing in late fall often remain for weeks within the stems. The beetle escapes from the cavity by eating an irregular opening in the wall of the stem. This opening is usually about one-fourth larger than the diameter of the adult itself.

When issuing from the pupa, the adult is very light colored. The wing coverings are soft and of a whitish-yellow color. The head and thorax are light orange; the eyes and antennæ are black, which causes them to stand out distinctly against the general body color. In from 4 to 6 hours the wing coverings become a shining black, and the head and thorax gradually turn a much darker orange color and finally reddish. Usually within a day's time the adult has completely hardened and taken on all the characteristic adult colors.

In the case of the earlier generations, the adults after issuing feed for a period of 6 to 8 days, after which copulation takes place, and in from 3 to 7 days more the act of oviposition is accomplished. The adults often copulate several times before eggs are finally deposited.

FEEDING HABITS OF ADULTS.

In the past, the adults have generally been considered to feed upon pollen only, and while this is their important food, yet as Folsom first reported, they are often, in the spring of the year, observed to eat the foliage of their host plant. The authors have also observed the adults feeding at the oviposition puncture. This fact in itself is significant because of the size of the opening which the female makes previous to oviposition. Often this opening is so large that the stem splits and breaks at this point. Although it is likely that the adults will feed upon pollen of almost all available blossoms, yet a list of those plants upon which it has been known to feed is of considerable interest. The authors have noted it feeding on the bloom of alfalfa, yellow sweet clover, wild barley, sunflower, and prickly lettuce. Other members of the Bureau of Entomology have made records on the feeding habits of the adults as follows:

T. H. Parks	Red clover.
W. E. Pennington	Wheat heads.
L. P. Rockwood	Corn silk.

THE ADULTS SECLUSIVE.

The adults are very seclusive in their habits. They usually make use of the early morning hours for their feeding, while the act of oviposition nearly always is accomplished in the late evening or at

night. They invariably seem to avoid excessive temperature and sunlight, and when disturbed immediately drop to the ground and feign death. They remain in this motionless position for a long period of time and in fact almost seem to know instinctively when a person is looking at them.

OVIPOSITION.

The adults prefer young succulent alfalfa stems for oviposition. The female before ovipositing prepares a rather large nidus in the stem. This consists of two parts: The outer larger portion which is about one-eighth of an inch square and is only eaten through the epidermis and plant tissues immediately adhering thereto, and a smaller round opening in the center of this outer square about one-sixteenth of an inch in diameter, which extends to the pith of the stem. The adult is thus enabled to introduce her head and thorax within the stem and hollow out a cavity in the pith for placing the egg. This cavity is usually one-fourth of an inch in length and evidently is for the purpose of affording the newly hatched larva a place for locomotion and feeding.

After preparing the egg receptacle, the female deposits the egg, usually just below the external orifice and on the opposite wall of the stem. After ovipositing, the female teases out the tissues on the edge of the inner or round opening so that they practically close the hole. A fresh oviposition puncture is almost white or colorless in appearance, but after 36 to 48 hours it becomes a dark brown spot, and at all times is conspicuous and easily noted, especially after the dark color has been assumed. During periods of heavy summer rainfall and excessive humidity the alfalfa stem often splits open each way from the oviposition puncture, and the stem breaks over and is entirely destroyed. In this case, the larva fails to develop.

During the authors' observations and those of other members of the bureau, more than one egg has never been noted as being placed through one oviposition puncture. Two oviposition punctures sometimes occur in the same stem, but in each case one larva always destroys the other, and thus only one beetle develops in a single alfalfa stalk. A. A. Girault (15), who has made an interesting observation upon the oviposition habits of this species, has noted at least 15 eggs deposited through a single opening within the stem of a species of Leucanthemum. This is described by him as follows:

> After preparing the nidus, the female leisurely walks up the stem the length of her body, and after feeling a little, fits the tip of the abdomen into the excavation and places an egg. After depositing she wheels in her tracks with almost military precision, simply reversing her position and commences to prepare another place for an egg in the same excavation. The female works with economy, wheeling about

each time, so that the tip of the abdomen approached the excavation at each deposition, and then again to the rear, so that the jaws would strike the excavation when about to prepare a place for the next egg. Thus, in preparing the cavity, the beetle was facing up, with her body below it; when about to deposit the first egg she simply moved forward the length of her body, and afterwards simply wheeled in her tracks, when about to prepare a place for the second egg. The succeeding depositions were executed by wheeling about each time. Therefore, each completed movement, consisting of two wheels to the rear, accomplished the deposition of two eggs, occupying about 4½ minutes.

SEASONAL HISTORY.

A study of the seasonal history of this insect in the southwestern United States is especially interesting because of the bearing it has upon the control of the species.

There is present, especially in the Salt River Valley of Arizona, along ditch banks, fence rows, and all waste places in the spring of the year, a luxuriant growth of yellow sweet clover (*Melilotus officinalis*) (Pl. I, fig. 1). Hibernating beetles, upon their appearance in early March, find this sweet clover growing in the immediate vicinity of their winter quarters, and consequently, when the reproductive instinct asserts itself, they begin ovipositing in this plant, the growth of which is at the proper stage for their purpose. The first generation of these beetles is, therefore, passed almost entirely upon this plant.

The date of emergence of the beetles depends quite largely upon conditions of temperature. During the spring of 1915, on March 12, beetles were found by the senior author to be still hibernating and they did not begin their activities for at least 10 days following this date. During 1916, on the other hand, eggs were found in yellow sweet clover by the junior author on March 9, and in the same year larvæ were taken in the field on March 15. The average mean temperature, at Tempe, Ariz., from February 1, 1915, to March 12, 1915, was 52° F., while the average mean temperature from February 1, 1916, to March 9, 1916, was 59° F.

In the eastern United States this beetle has only one generation annually. A review of observations by several writers shows that hibernating beetles come forth in late April or early May, eggs are deposited soon thereafter, and by late June larvæ are usually abundant. By August 1 pupæ are present and in early August the new adults begin to appear. These continue to emerge until late September, and soon after the appearance of heavy frosts the species is again in hibernation.

This insect in the southwestern United States has three distinct generations annually. As has already been mentioned, the first generation is passed almost exclusively upon yellow sweet clover, while the second and third generations are passed upon alfalfa and other plants, the majority of which are weeds. Where alfalfa is found, in

FIG. 1.—IRRIGATION DITCH OVERGROWN WITH YELLOW SWEET CLOVER AND COMMON MALVA, GIVING RISE TO FIRST GENERATION OF THE CLOVER STEM-BORER (LANGURIA MOZARDI).

FIG. 2.—IRRIGATION DITCH BANK FENCED AND PASTURED BY THE USE OF SHEEP, ELIMINATING WEEDS AND WASTE GROWTH AND PREVENTING INSECT DEVELOPMENT IN SUCH LOCATIONS.

the month of March and early April, of the proper size and maturity, beetles, which have come from their hibernation quarters, will also oviposit in alfalfa, and a small percentage of them have been found ovipositing in the common mallow (*Malva rotundifolia*).

Adults of the first generation are found issuing in early May, the earliest date upon which adults have been observed to issue being April 26, 1916, by the junior author. In a week to 10 days after issuing, adults again are ovipositing; the second generation immediately follows, and by early June larvæ of this generation are found in immense numbers in infested alfalfa fields. It is the first generation, and the early broods of the second generation that do the largest damage to alfalfa, since the third generation usually is parasitized quite heavily. Beetles of the second generation begin appearing any time after the middle of July and start oviposition for the third generation which gives rise to beetles early in the fall. It is thought that at times this fall generation of beetles also oviposits before going into winter quarters, yet it has been impossible to be sure of this owing to the fact that later-appearing beetles of the second generation have also been known to survive until early September and continue their oviposition activities until that date. The latest date on which eggs have been taken in the field is September 6, 1916, while pupæ have been dissected from field-grown alfalfa stems as late as the last week in October.

It is thus to be noted that there is a considerable intermingling of the second and third generations, so that under field conditions they are not separate and distinct. Both the parent beetles and beetles of a new generation may be found ovipositing in the same field, and it was only by careful cage observations that the three distinct generations were secured. While indications point toward a possible fourth generation, yet this was not conclusively proven to the satisfaction of either author. By early November of most years beetles have gone into hibernation and can not be found in the field.

HIBERNATION.

These borer beetles have been observed hibernating in almost any place where they have sufficient cover to protect them from the freezing temperatures of winter.

C. M. Packard, of the Bureau of Entomology, has found them at Hagerstown, Md., hibernating under stones in wheat fields and in grass along railroad right of ways. D. J. Caffrey captured two adults at the edge of a wheat stack at Tempe, Ariz., while T. S. Wilson, likewise of the bureau, found an adult of this species in wild barley along a fence row.

The junior author maintained a large winter cage containing beetles of the clover stem-borer, and from these cage records it was

observed that from November 26 to February 18 these beetles were found hibernating "under clods, leaves, sticks, etc., often going into loose ground but generally only under some surface rubbish where most of the time is spent in a semidormant condition." Hibernating adults have been taken by the senior author along fence rows overgrown by weeds or rubbish of any kind.

A few records are available showing that this insect, on certain occasions, passes the winter in the larval stage. Dr. F. H. Chittenden found larvæ remaining in stems of ragweed from November to April, while the junior author dissected a full-grown live larva from an alfalfa stem the latter part of December, 1915, and this larva when placed in another stem continued its development, pupating early in March. It is thus seen that it is altogether possible for this species to hibernate as a larva, but its normal habit is to pass the winter as an adult.

REARING METHODS.

Cages for confining adults for oviposition were made by placing two glass gas-light chimneys end to end and fastening them by adhesive tape. These were then placed over an alfalfa plant growing under natural conditions, and the upper end of the chimney was covered by muslin. Into this the adults were placed and allowed to remain overnight. Thus, any eggs deposited were secured almost immediately after being laid. The eggs were then removed from the alfalfa stalk and placed either on moist blotting paper or in a small cavity within a plaster of Paris salve box. The larvæ, upon hatching, were placed within stems of alfalfa. These stems were dissected day after day, and each day the larvæ placed in fresh stems. A small plug of absorbent cotton was used to close the upper end of the stem, while the lower end was placed in a vial of water.

Pupæ kept within small (9 by 36 mm.) vials containing a piece of slightly moist blotting paper developed very successfully. As has been mentioned elsewhere in this paper, a great many attempts were made to rear larvæ by placing them within a split alfalfa stem, the open side of which was placed against the side of a glass tube and the lower end in a small vial of water, the larvæ in this cage being continually under observation. Although these conditions seemed to be very abnormal, yet a certain amount of success was experienced by the use of this type of cage.

Generation records were secured by placing a wire screen cage (3 by 3 by 3 feet) (fig. 5) over alfalfa growing under normal conditions. Adults were placed in this cage for a definite period of time and then removed. Additional records were obtained by stem dissections at the time pupæ were thought to be present, and these were used for securing the adults of a new generation.

NATURAL ENEMIES.

TOADS.

The clover stem-borer, like many of our older native species, is in a great majority of cases kept in check by its natural enemies. During the past few years practically every toad that has been killed by any of the men carrying on this investigation has had several adults of this beetle within its stomach. Tyler (11) has reported this species as being present in the stomachs of toads. Doubtless these batrachians eat a great many Languriæ during the course of a year, and because of the fact that toads are largely insect feeders, they are deserving of careful protection from farmers.

BIRDS.

The Bureau of Biological Survey has found specimens of *Languria mozardi* in the stomachs of the following species of birds: Traill flycatcher (*Empidonax trailli*), starling (*Sturnus vulgaris*), meadowlark (*Sturnella magna*), mockingbird (*Mimus polyglottos*), Carolina wren (*Thryothorus ludovicianus*), and robin (*Planesticus migratorius*).

PARASITES.

The most important natural enemies, however, that aid in controlling this species are its hymenopterous parasites.

In his early observations upon this species, Prof. Comstock (8, p. 199) noted that:

> Two parasites were found within the burrows of the stalk borers, the one a small black chalcid, the dark, naked pupa of which was often met with, and the other a yellowish ichneumonid, the pupa of which was inclosed in a delicate white silken cocoon.

In 1890 Weed (13) also reported a black chalcid as an external pupal parasite. This was doubtless the same species as that reported by Comstock a good many years previously. Folsom (16), in 1909, again noted the black chalcid in considerable numbers, this being evidently the same one referred to by Weed and Comstock. Folsom also took an ichneumonid cocoon from a Languria burrow which disclosed an adult after a pupal period of 4 days. Among the Bureau records we find one by C. V. Riley, who reared a scelinid larval parasite.

Habrocytus languriæ.

The authors of the present paper have noted three rather important parasites of this species. *Habrocytus languriæ* Ashm. (fig. 6) is without doubt of the greatest importance. Often as high as 30 per cent of the larvæ of Languria are parasitized by this species.

The Habrocytus adult oviposits through the wall of the alfalfa stem into the tunnel occupied by the Languria larva, and within

from 2 to 3 days the parasite larva hatches and immediately searches out its Languria host.

The duration of the larval period during the month of June was found to be 8 days, with an average mean temperature of 81° F., while the larval stage length of another specimen was 13 days, from March 28 to April 10, during a mean temperature of 60° F.

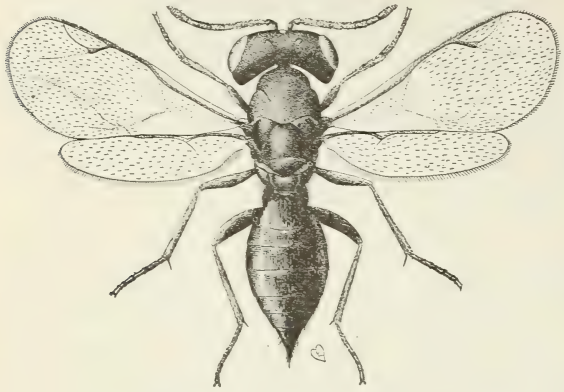

FIG. 6.—*Habrocytus languriae*, a parasite of the clover stem-borer.

The pupa is free and the stage is passed within the Languria burrow. The pupal stage length of 6 specimens averaged 9⅔ days, while a single specimen, during the month of April, had a pupal stage length of 19 days. The records are given in Table VII, which follows:

TABLE VII.—*Length of pupal period of the parasite Habrocytus languriae.*

Pupated.	Adult issued.	Pupal period.	Average mean temperature.
1916.	1916.	*Days.*	°*F.*
May 8	May 17	9	72
Do.	May 16	8	72
May 9	May 18	9	72
May 13	May 24	11	70
May 16	May 27	11	69
June 30	July 10	10	86
April 10	April 29	19	68

OTHER PARASITES.

The next most important parasite reared from Languria larvæ was *Heterospilus* sp. This was first reared by the senior author in 1912, and again in September, 1915, by the junior author. Three specimens of *Eurytoma* sp. were reared by the junior author during August, 1915, from Languria larvæ, while the senior author in May, 1916, reared the same species from the larvæ of *Habrocytus languriae*. In this case it had a larval stage of 10 days and a pupal stage of 13 days, and, as is noted, was a distinctly secondary parasite. The value of this parasite, therefore, in keeping *Languria mozardi* in check is questionable, since it is both primary and secondary in habits. The

same is true of the parasite *Eupelmus allynii* French. This species was reared by the senior author during August, 1912, as both a primary and secondary parasite of Languria feeding upon the Languria larvæ and also upon larvæ of the primary parasite (*Habrocytus languriae*). The pupal stage of this Eupelmus was 10 days during the month of August.

While the primary parasites undoubtedly are of considerable benefit in controlling this beetle, it must not be supposed that vigorous efforts on the part of the alfalfa grower are not necessary to effect the satisfactory subjection of the pest.

CONTROL MEASURES.

As early as 1879 Prof. Comstock (8, p. 200) gave us the key to the control of this species when he stated:

> It seems probable that where clover is regularly cut in early summer and again in fall this insect will not increase to any alarming extent; but where this is neglected, or where there is much waste clover, it may do considerable damage.

In other words, Prof. Comstock recognized the fact that in case clover was cut when it was in a prime condition, a large number of the Languria borer larvæ within the clover stems would be destroyed.

As regards the control of this species upon red clover, Prof. Folsom (16) writes as follows:

> Every year the farmer unknowingly kills off large numbers of these insects when he cuts his hay crop, whether he cuts it early or late, for in the latter part of June and throughout July in this latitude the great majority of the insects are inside the clover stems as larvæ or pupæ. The old beetles from the previous year are practically gone by July 5, and the new beetles do not issue from the stems until about the 1st of August. If the cutting of the hay crop is neglected, however, and left far into July, much of the clover will be flat on the ground from the work of this insect. I had this tested on the university farm, and when the clover was cut, heard from the man who mowed the field certain appropriate comments upon the amount of clover which had lodged.
>
> If the red clover is cut when it should be—to make the best fodder—only about three stems in a hundred of the new growth will show the insect. To find many larvæ in July and early August one has to search in uncut field clover or in clover growing wild on the border of a field or by the side of the road or the railroad track. The practice of mowing and destroying volunteer clover is well worth the little time that it takes.

Owing to the habits of this insect, it has not been found possible to use any poison against it for purposes of control. The means at our disposal is a regulation of the general farm practices which, of course, takes into consideration the habits and life history of the insect so that the larvæ will be destroyed before completing their development either in the main body of alfalfa and clover fields or in neglected waste places.

DESTROYING SWEET CLOVER, WEEDS, AND WASTE ALFALFA.

As has been already pointed out, the first brood of the clover stem-borer in the southwestern United States is largely passed upon yellow sweet clover, while portions of the other broods in this same section, as well as other sections of the country, develop upon various kinds of weeds. It is thus readily seen that if that portion of the first generation or brood upon yellow sweet clover is entirely eliminated by cutting down, pasturing, or otherwise destroying all sweet clover growing along ditch banks, roadsides, and fence rows, then there will be many less females to oviposit in the oncoming crops of alfalfa or clover.

A great many farmers, in cutting either an alfalfa or clover hay crop, allow a strip to remain uncut along fence rows and ditch banks, and in these places all borers that are present and which are able to escape their parasites are allowed to go through to the adult stage in a thrifty condition. Thus, such places serve as continual sources of infestation for the new coming alfalfa crop. Where stock is available, a great many farmers are in the habit of turning cattle into a hay field for a few days immediately after removing a hay crop, allowing these to clean up completely all alfalfa which remains standing or falls on the ground. This is a very excellent practice and one that should be encouraged at all times. In case cattle are not available, then this waste alfalfa or red clover should be cut either by scythe or hand sickle and removed from the ground with the hay crop.

In irrigated regions where the farmer is continually confronted with weeds, clover, and waste alfalfa growing upon ditch banks, two very excellent methods of control for keeping these places free from weeds are available: One is to cultivate the ditches and ditch banks continually, thus keeping down all foreign growth; another method, and one that can be accomplished with benefit to the rancher, is that of fencing all ditch banks and pasturing, preferably by sheep, which are adept at keeping down waste growth. (See Pl. I, figs. 2 and 3.)

HARVESTING METHODS.

It is well to point out at this time that where alfalfa or clover is pastured the borers are unable to develop. It is only in waste places or where haying is practiced that they are able to reach maturity.

HAYING.

If the farmer will acquaint himself with the nature of the injury done by this insect in either alfalfa or red clover hay and the appearance of the egg holes in the stems, then when these are found in numbers he will take pains to cut his alfalfa or red clover when it is in the height of its nutritive value, which in the case of red clover is

when the crop is in full bloom, and in the case of alfalfa when the crop is about one-tenth in bloom. Then, provided that the land has in the past received proper cultivation and crop rotation, and the crop is a thrifty growing one, the borers will not have been able to develop to adults before the hay crop is removed, and thus, as has been shown in the previous discussion of larval habits, all larvæ and pupæ will be destroyed.

Where an alfalfa or clover crop is let go to seed, conditions are ideal for the development of adults, and if the farmer is producing seed, there is no remedy for this except that the beetle must be controlled in all waste places and adjoining hay fields. If this practice is followed, there will be but few beetles to oviposit in seed fields, and hence the damage will be reduced to a minimum.

BURNING RUBBISH.

Since these beetles pass their winter stage under rubbish, grass, etc., the farmers of any section of the country should make it a point, each fall or early in the winter when the frost has killed all weeds and grasses, to burn or otherwise destroy all grass, weeds, and rubbish in waste places such as roadsides and ditch banks, and eliminate these places of hibernation, thus reducing the numbers of beetles as well as other insect pests.

CROP ROTATION.

In the red clover growing sections of the country, proper systems of rotation have already been well developed and are used, as a general rule; but in a great many of the large alfalfa districts of the West and Southwest, farmers are too prone to allow alfalfa to stand in the same field for a number of years without rotating it with some other crop or crops. Where such conditions prevail, the land becomes "alfalfa-sick," and the crop does not grow in as thrifty a manner as it would were the land planted to some other crop during a certain series of years. In the clover districts this is well emphasized, and alfalfa growers should take a lesson from clover growers.

Where alfalfa is to be used as the hay crop, a rotation can be arranged to cover a much longer period of years than where red clover is used as a hay crop, since alfalfa can be left on the ground without a reduction in stand for a much longer time than can red clover. The advent of Egyptian cotton culture in the valleys of the southwestern United States is doing much toward readjusting the plan of farm work, and the time is not far distant when a system of crop rotation will be evolved that will include both cotton and alfalfa in the rotation plan to the benefit of both crops and the elimination of many insect pests affecting them.

SUMMARY.

The clover stem-borer has been known for a good many years as an enemy of red clover. Recently it has attracted attention as an enemy of alfalfa, especially in the southwestern semiarid regions of the United States where irrigation has made possible the growing of large acreages of alfalfa. The larvæ or young of the borer injure the plant by boring out the center of the stems of both alfalfa and clover.

The insect is widely distributed throughout the United States and parts of Canada and Mexico, and has a large cosmopolitan list of food plants.

The eggs are deposited in the stem through a small opening prepared in the host plant by the adult female.

The larvæ are found feeding within the stems of the host plant, first upon the pith and then upon the plant tissues surrounding the pith, and they move up and down the stem throughout its length.

The pupal stage is passed in cells, 6 to 8 inches long, within the stems where the larvæ have passed their lives.

The adults hibernate under rubbish along fence rows, ditch banks, or other waste places.

In the eastern United States this insect has one generation each year; in the southwestern United States there were found to be three distinct generations each year. The first generation in the southwestern United States is passed almost entirely upon yellow sweet clover, and the beetle can be greatly reduced in numbers by destroying this weed pest.

The injury to alfalfa and red clover can be partially eliminated by destroying sweet clover, weeds, and waste alfalfa. The damage also can be reduced greatly by cutting a hay crop before the larvæ have had an opportunity to complete their development. The practicing of proper methods of crop rotation as well as cleanliness of farming, such as burning rubbish, etc., will also cause a reduction in numbers of this beetle. The beetle is unable to develop where pasturing is practiced continuously.

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